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Research on the cooperative game between tourist spot's public operational vehicles and private operational vehicles

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Abstract

Tourist spot's public operational vehicles occupy the monopoly position in the market of tourist passenger transport, but they have a great defect of service quality which has a bad influence on the positive image of the tourist spot. Introducing private operational vehicles into the market is suggested which makes a corporate operation of public operational vehicles and private operational vehicles. Based on this, a cooperative game model is proposed and a kind of cooperation mode which makes the profit distribution reasonable and the alliance stable is sought. The results indicate that the formation of cooperative alliance can increase the profit of both sides and can increase the overall social benefits of tourist spot simultaneously.

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Keywords: Cooperative Game; Tourist Spot; Passenger Transport; Private Operational Vehicles

1 Introduction

With the improvement of living standard，people's travel demand is increasing which results on the rapid growth of tourist spot's reception of tourists. Tourist passenger transport develops simultaneously as a part of tourist industry. Tourist passenger transport includes road tourist passenger transport and tourist spot passenger transport. Road tourist passenger transport is the displacement transfer process traveling from the residence to tourist destination; tourist spot passenger transport is the displacement transfer process traveling among the tourist attractions within tourist spot.

But the tourist spot passenger transport begins to confront a great challenge with the rapid development of tourist industry. Travelers have met a series of problems when they take tourism transportation, such as the overcrowded compartment, poor attitude of the staff, the single option of transport vehicle type and the vehicle's failure in departure or arrival on time which greatly reduce the satisfaction of the travelers on the tourist spot and is not conducive to the positive image transmission of tourist spot. Consequently, a good organization and coordination of the tourist passenger transport is of great significance.

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At present, the research about tourist passenger transport is mainly on the road tourist passenger transport, theory research on tourist passenger transport[1], tourist passenger transport pricing[2][3], research on the behavior of tourist spot transport mode choice[4]. While the research about the tourist spot passenger transport is very few which only limited to the development and layout of the passenger line[5].

For the current phenomenon that tourist spot's public operational vehicles occupy monopoly situation, this paper recommends the full introduction of private operational vehicles to force the competition under cooperative condition. After analyzing the business behavior of both sides with cooperative theory, a cooperative game model aiming at the largest joint effectiveness is built. Finally, the Mount Emei Scenic Area, Sichuan, China is selected as a case study, then the best solution of the cooperative game model about tourist spot public operational vehicles and private operational vehicles is obtained.

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2 About cooperative game theory

Cooperative game is a game that the interests of both sides increase or at least one party's interests increases in the condition that the other party will not be harmed, therefore the overall interests increases. Two-person bargain is the basic problem of cooperative game, it is a problem about how to divide the interrelated gains (profit) between two players, that is to say, achieve greater co-interest and self-interest of both sides by coordinating behaviors with a contract in the situation that they have common but not entirely consistent interests.

Public operational vehicles are owned by tourist spot and the operating income belongs to tourist spot, private operational vehicles are owned by individuals and the operating income belongs to individuals. Both incomes are related to the quantity of the passengers they carried. In fact, it is the segmentation of tourist spot passenger market. The competition between the tourist spot public operational vehicles and private operational vehicles is a kind of game, both sides are considering how to improve their income in the competitive process. Currently, public operational vehicles and private operational vehicles are in the opposite position and both sides are snatching passenger transport market through a variety of means. Some unreasonable behaviors lead to the dissatisfaction of tourists which will easily result in the loss of tourists causing the shrink of entire passenger travel market.

Actually, the relationship between tourist spot public operational vehicles and private operational vehicles can transform to cooperative game. If the overall passenger number increases, the income of both sides will increase, which is their common interests. However they differ in travel time and price when compete with each other, so their interests are not exactly consistent. Thus, the tourist spot public operational vehicles and private operational vehicles can be taken as a two-person bargaining game. If a cooperation agreement which offer a cooperative way to have a reasonable split of gains achieving the increase of interests of the two sides ultimately can be reached, then this cooperative method can be long-term implementation and the cooperative alliance can be stable, at the same time, the healthy development of the tourist spot passenger market can be promoted.

3 Game analysis on tourist spot's public operational vehicles and private operational vehicles

The basic elements of two-person bargain problem: (1) Feasible alternative set S. The feasible allocation set of two-person bargain is given by $S=\left\{(s_1,s_2)\middle|0\le s_i\le m, s_1+s_2\le m\right\}$, s_1 and s_2 represent the benefit of two sides respectively, m represents the maximum divisible benefits. (2) The expected utility of players is given by u_i. Generally,

u_i is a function of their own benefit, $u_i = u_i(s_i)$. (3) Disagreement point d. Disagreement point is given by $d = (d_1, d_2)$, d_i represents the benefit of player i when the negotiation is broke down. Cooperative game makes no sense when the utility brought by bargaining game is less than that of disagreement point because it is not be able to achieve better results than individual rational game.

For the two-person bargain cooperative game about public operational vehicles and private operational vehicles, its result depends on the joint rational behavior of game players. So, cooperative game analysis should focus on the joint rational behavior and the results of two sides rather than individual rational decision-making. In addition, what kind of distribution and utility configuration is most likely to be accepted by the game players should be studied. The cooperative game model about scenic public operational vehicles and private operational vehicles is built in this paper to segment the scenic tourist passenger market, namely to assign the volume of passenger traffic to the public operational vehicles and private operational vehicles making the utility is greater after the cooperation.

4 Cooperative game model formulation

4.1 Fundamental assumption

The cooperative game model about public operational vehicles and private operational vehicles built in this paper is based on the following assumptions: (1) the two game players both are rational and only accept solution of which the utility is better than current case. (2) There is no difference in the players' risk appetite and risk-neutral character with no risk aversion is assumed here. (3) The utility function (the benefit of game players) of players are just the function of the number of passengers carried, that is to say, benefit =price×passenger capacity. (4) Travelers only consider three aspects, traveling expenses, waiting time and travel time and cabin environment which correspond to the economy, punctuality and comfort respectively when they choose the tourist spot transportation. (5) Assume that the travelers who choose private operational vehicles are absolutely satisfied with the tourist spot because of the high service quality of private operational vehicles. Moreover, part of the travelers will have a positive publicity about tourist spot which drives the increase in the number of tourists. Public operational vehicles have a lower fare while the overlong waiting time and poor comfort will reduce the satisfaction of tourists to tourist spot. It is assumed that the two sides are equal in the course of the game because they have their own different competitive advantages.

4.2 Parameters

Model parameters are described below：

N The average daily passenger capacity，namely the total number of tourists who take the tourist spot public operational vehicles and private operational vehicles.

T The total time of the transport vehicle which includes waiting time and vehicle travel time characterizes the punctuality of the transport vehicle.

t The monetary value of the total time of the transport vehicle when it is converted into the currency.

p The fare of the transportation which characterizes its economy.

$\lim 1$、$\lim 2$ Represent the price ceiling of public operational vehicles and private operational vehicles respectively. In another word, the tourist spot have to not support excessive fare for the welfare of people.

c A parameter about comfort which values between 0-1. If the cabin environment is more comfortable, the value of c is greater.

w_1、w_2、w_3 The weight of punctuality, economy, comfort in the cost function which can be regarded as the importance of these factors when choose transportation and the value of w derives from the existing literature.

f_i The cost spent by travelers when choose transport vehicle i , $i=1$ represents public operational vehicles and $i=2$ represents private operational vehicles.

U_i The benefits obtained by travelers when choose transport vehicles i .

θ The conversion parameter of the cost function and passenger benefit function which values between 0-1. Greater value means that travelers are more sensitive to costs, that is to say, the travelers feel smaller discrepancy due to the different cost. It is assumed that all travelers' cost sensitivity are the same for the less complexity of this model and the value is $\theta=1$.

s_i The proportion of travelers who choose transport vehicle i , namely the market share occupied by the transport vehicle i . It equals the probability of travelers choosing transport vehicles i .

$u_i(s)$ The utility of player i which is a function of the market share， $u_i(s)=s_i\cdot N\cdot p$.

d_i The market share of transport vehicle i in the current situation of non-cooperation.

M The income increased which is brought by adding each tourist and it is given by ticket income here.

PO_1 、 PO_2 The fare of public operational vehicles and private operational vehicles under the current condition of non-cooperation.

p_1 、 p_2 Decision variable. The value of p which represents the fare of transport vehicles after cooperation decides the market share s_1 、 s_2 of players.

r The number of additional visitors caused by the positive word-of-mouth of each satisfied traveler.

q Intensity of the dissemination of information denotes the probability of positive word-of-mouth publicity which is performed by travelers.

k The level of the acception of positive message when spread to the potential visitors. If a potential visitor fully accepts the tourist spot positive message he will become a tourist spot visitor.

l The friends who are willing to travel to the tourist spot in the communication circle of tourists. BO_1 、 BO_2 The benefit of public operational vehicles and private operational vehicles under the current condition of non-cooperation.

B_1 、 B_2 The benefit of public operational vehicles and private operational vehicles after cooperation.

4.3 Cooperative game model

The basic model to solve cooperative game "Nash bargaining solution "can be given by a optimization mathematical model as follows:

$$\max=\left[(u_1(s_1)-u_1(d_1))\cdot(u_2(s_2)-u_2(d_2))\right] \quad (1)$$

S.T. $s_1+s_2=1$ （2）

$$u_1(s_1)\geq u_1(d_1 \quad (3)$$

$$u_2(s_2) \geq u_2(d_2) \tag{4}$$

In the competitive market conditions, travelers will choose transport vehicles which offer maximum benefits. In order to reduce the computational complexity, the market share occupied by transport vehicles is represented by the passenger selection probability of transport vehicles. The passenger selection probability of transport vehicles is described by Logit model which is based on random utility theory. The time is converted into monetary costs basing on the assumption that the time value of travelers is 30 RMB per hour, namely $t = 30T$.

The cost spent by travelers when choose transport vehicle i is $f_i = w_1 t_i + w_2 p_i - w_3 c_i$. The benefits obtained by travelers when choose transport vehicles i is $U_i = -\theta f_i$.

In this paper, $\theta = 1$, then the passenger selection probability of transport vehicles i (the market share occupied by transport vehicles i) is given as follows:

$$s_i = \frac{e^{-\theta f_i}}{e^{-\theta f_1} + e^{-\theta f_2}} = \frac{e^{-(w_1 t_i + w_2 p_i - w_3 c_i)}}{e^{-(w_1 t_1 + w_2 p_1 - w_3 c_1)} + e^{-(w_1 t_2 + w_2 p_2 - w_3 c_2)}} \tag{5}$$

The utility of the two game players under the current condition of non-cooperation is given as follows:

$$u_i(d_i) = PO_i \cdot d_i \cdot N \tag{6}$$

If the two sides build a cooperation allowing private operational vehicles fully enter into the passenger market, the travelers who choose private operational vehicles will increase which results in that the number of satisfied visitors also increase. According to the rules of positive word-of-mouth spread, the number of tourist spot visitors will increase due to the positive publicity on the tourist spot and the word-of-mouth effect follows certain rules. Additional number of tourists which is increased by each satisfied traveler with positive word-of-mouth effect is given by r . According to the theoretical model of word-of-mouth effect, $r = q \cdot k \cdot l$. The income of tourist spot increased due to the increase of tourists is $s_2 N \cdot r \cdot M$ .The gains of public vehicles is replaced by the gains of tourist spot because the operating income of public vehicles and ticket revenue belong to the tourist spot $u_1(s_1) = s_1 \cdot N \cdot p_1 + s_2 \cdot N \cdot qkl \cdot M$ (7)

Plug equation (5),(6),(7) into equation (1),(2),(3),(4), then the final mathematical model about the cooperative game of tourist spot public vehicles and private vehicles can be given as follows:

$$\max = \left[((p_1 s_1 N + s_2 N \cdot qkl \cdot M) - PO_1 d_1 N) \cdot (s_2 p_2 N - PO_2 d_2 N) \right] \tag{8}$$

S.T. $s_1 + s_2 = 1$ (9)

$$0 \leq s_1 < 1,\ 0 \leq s_2 < 1 \tag{10}$$

$$(s_1 p_1 N + s_2 N \cdot qkl \cdot M) \geq PO_1 d_1 N \tag{11}$$

$$p_2 s_2 N \geq PO_2 d_2 N \tag{12}$$

$$s_1 = \frac{e^{-(w_1 t_1 + w_2 p_1 - w_3 c_1)}}{e^{-(w_1 t_1 + w_2 p_1 - w_3 c_1)} + e^{-(w_1 t_2 + w_2 p_2 - w_3 c_2)}} \tag{13}$$

$$p_1 \le p_2 \tag{14}$$

$$0 \le p_1 \le \lim 1, 0 \le p_2 \le \lim 2 \tag{15}$$

Equation (8) is the objective function which represents the maximum joint benefit of public operational vehicles and private operational vehicles. Constraint (9) ensures that the sum of the market share occupied by the two sides is 100%. Constraint (10) requires that any side cannot hold the whole tourist passenger transport market. Constraint (11) and (12) ensure that the gain of the two sides after cooperation is greater than current gains. Constraint (13) shows the relationship between market share and transport fare. Constraint (14) is used to guarantee a higher fare of private vehicles because private vehicles are more comfortable and speedily than private vehicles. Constraint (15) requires that the final cooperative price can not be higher than the price cap according to the relevant provision.

5 Case study

5.1 Data analysis

Mount Emei Scenic Area, Sichuan Province, China is selected as a case study and the relevant data is obtained from Sichuan Provincial Tourism Bureau and the statistics of the Mount Emei Scenic Area. According to the current operational passenger line of the Mount Emei Scenic, select the section of Wannian Temple station to Baoguo Temple station as a research subject which is 10 kilometers approximately. The waiting time and travel time of public operational vehicles are 30 minutes and 40 minutes respectively and its fare is 20(RMB). The waiting time of private operational vehicles whose fare is 45(RMB) is 10 minutes and travel time is no more than 30 minutes. According to statistics, about 80% of the travelers in this section take the tourist spot public operational vehicles in the current situation. The current fare of Mount Emei Scenic Area prices at 150(RMB).

For the comfort factor of public and private operational vehicles, c is given by $c_1 = 0.7, c_2 = 1$. What's more, in order to reduce computational complexity, the parameters about positive word-of-mouth effect and weight of punctuality, economy, comfort is valued according to the existing literature. The value of parameters is given in Table 1.

Table 1 The value of parameters

parameter	value	parameter	value	parameter	value	parameter	value
PO1	20（RMB）	M	150（RMB）	d1、d2	0.8 0.2	q	0.1
PO2	45（RMB）	T1、T2	1.16（h） 0.66（h）	lim1 lim2	[25,35] 60	k	0.2
C1 C2	0.7 1	W1 W2 W3	0.12 0.47 10	N	3161 (people)	l	5 (people)

5.2 Model solution

The cooperative game model is solved on a Core 2 computer with 1.86GHz and 1GB RAM using Lingo software.

When the price ceiling of public operational vehicles is 25(RMB), the model solution results are shown in Fig.1.

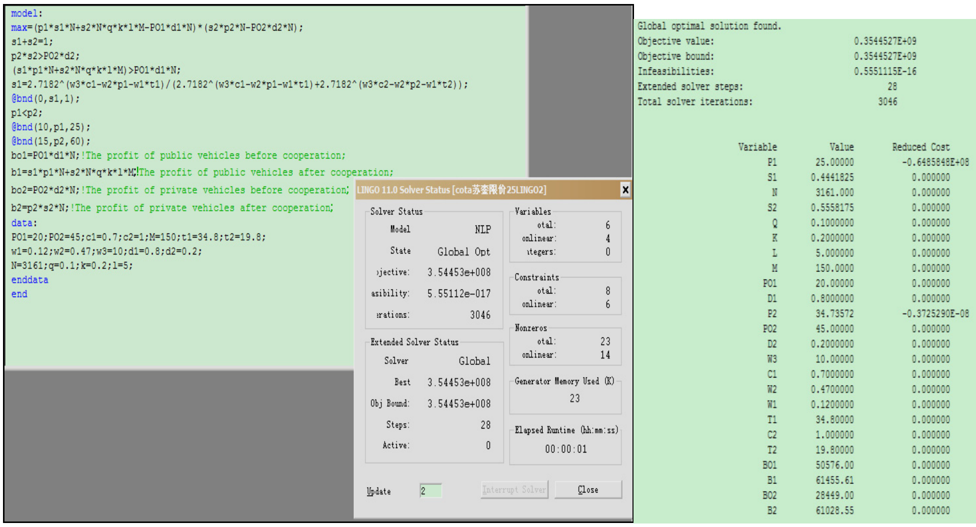

Fig.1. Model solution

The solving results indicate that the cooperative game model about tourist spot public operational vehicles and private operational vehicles established is nonlinear programming model (NLP) and it has a global optimal solution（Global Opt）. Different price ceiling of public operational vehicles go with different optimal price cooperation programs (see Table 2).

Table 2 The optimal cooperation programs with different price ceiling

	p_1	s_1	BO_1	B_1	p_2	s_2	BO_2	B_2
Lim1=25	25	0.4442	50576	61455.61	34.74	0.5558	28449	61028.55
Lim1=27	27	0.4426	50576	64205.30	36.72	0.5574	28449	64697.90
Lim1=29	29	0.4425	50576	66999.17	38.72	0.5575	28449	68232.46
Lim1=30	30	0.4428	50576	68410.38	39.72	0.5572	28449	69965.85
Lim1=32	32	0.4437	50576	71257.72	41.73	0.5563	28449	73384.31
Lim1=34	34	0.4449	50576	74134.25	43.74	0.5551	28449	76754.70
Lim1=35	35	0.4455	50576	75582.19	44.75	0.5545	28449	78426.18

Conclusions can be drawn from the above solution results: (1) Different price ceiling of public operational vehicles（Lim1）goes with different optimal price cooperation program and the gains of the two sides after cooperation(B_1 、 B_2) both are greater than non-cooperation(BO_1 、 BO_2).(2) In any case, the joint benefit of the two sides goes most when the public operational vehicles and private operational vehicles occupy the market share(s_1 、 s_2) approximately 44% and 56% respectively, and the fare of private operational vehicles(p_2) is always higher than that of public operational vehicles(p_1) around 9.7(RMB).

6 Conclusions

The above calculating results indicate that the full introduction of private operational vehicles to build an alliance with tourist spot public operational vehicles and agreement on an optimal price program can obtain the most significant increase in individual income and joint benefit as well. The cooperative game model established about tourist spot public operational vehicles and private operational vehicles validates that the gains of the two players after cooperation are greater than that of non-cooperation. Moreover, the optimal cooperation program varies from different price ceiling of public operational vehicles which can be acquired based on this cooperative game model which provides effective theoretical reference for the tourist spot in finding the best price program which aims to the optimal benefit of whole tourist passenger market.

The cooperative game about tourist spot public operational vehicles and private operational vehicles studied in this paper is to have a re-segmentation of the scenic tourist passenger market by taking advantage of the adjustment of price. Actually, the adjustment of vehicle schedules will also have an influence in the passenger market share. Therefore, this research can be extended by a cooperative game model considering both fare and departure time interval of vehicles in the future.

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